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APPRENTICESHIP TRAINING

COMMUNICATION ELECTRICIAN Program

Toll Craft

Alberta
MANPOWER
Apprenticeship and
Trade Certification Division

DDN 5666416

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COMMUNICATION ELECTRICIAN TRADE
TOLL CRAFT

THE GOAL OF APPRENTICESHIP TRAINING

To develop a competent tradesman who, through skill and knowledge, is capable of installation, diagnosis and repair of equipment as used in the Toll Craft of the Telecommunication Industry.

THE PRODUCT OF APPRENTICESHIP— a graduate who will:

Have a thorough knowledge electrical and electronic theory and its application to communication and associated equipment used in the Toll Craft of the Telecommunication Industry.

* Be competent in the use of test instruments and understand their capabilities and limitations.

* Have the dexterity and skill to carry out the mechanical functions of completing repairs.

* Be familiar with the different circuit combinations and components.

* Be capable of utilizing test procedures to locate faults and isolate defective components.

* Understand the relationship and acquire appreciation of principles and concepts as applied to equipment in various craft areas of the trade.

COMMUNICATION ELECTRICIAN — TOLL CRAFT APPRENTICESHIP INFORMATION

Basic Requirements:

* Indenture for four periods of Trade experience.

* Attend a six week technical training course in the first, second, third and fourth periods.

* Fulfill the requirements for each period including 1800 hours of work experience inclusive of time spent at the training course; successfully complete the technical training course and obtain a satisfactory employer's report.

* Education — a minimum requirement is the completion of grade 11 with Mathematics 20 or its equivalent, or a pass on an equivalent entrance examination as prescribed by the trade regulation.

* Age — the minimum age for apprentices is 16 years. There is no upper age limit.

Credits:

* Accelerated patterns of apprenticeship may be granted for related technical training and/or experience.

Benefits:

* Apprenticeship is a learning-while-earning program. While working at the trade during apprenticeship, apprentices are assured by regulation of a minimum percentage of journeyman rates; 40% during the first period, 50% during the second period, 60% during the third period, 75% during the fourth period. Progress from one rate to the next takes place only after successful completion of all the requirements for each period.

* All apprentices 17 years of age and older are normally eligible for training allowances while attending technical training courses. These allowances are funded by the Canada Employment and Immigration Commission.

* Administrative procedures establishing the amount of training allowance is complex and can vary with an individual's circumstances. Contact a local Canada Employment Centre for details.

* An apprentice who successfully completes the program will graduate with an Alberta Completion of Apprenticeship Certificate and a Journeyman Certificate of Qualification.

* The most significant benefit to the graduate apprentice is that he is well trained in technical and practical aspects of the trade and is able to make a worthwhile and productive contribution to society. Society in return, will provide an opportunity for an above-average income and successful livelihood.

DIRECTIONS FOR PROSPECTIVE APPRENTICES

* Contact your nearest Apprenticeship and Trade Certification Division office for detailed information and counselling (see list of offices on page 55).

* Obtain application forms in duplicate from the Apprenticeship and Trade Certification Division and neatly complete, on both copies, the information requested from the apprentice.

* Contact in person, firms that employ Communication Electricians and apply for an apprentice position. Present your apprentice application forms to the person who interviews you so that he will know who you are and what you can offer his firm.

* Persevere in the search for apprentice employment and upon obtaining employment, leave the application with the employer.

* Attach to the apprentice application a copy (transcript) of the marks for your last year of school. Applicants who do not have their school transcripts or a grade eleven standing are required to write an entrance examination. If transcripts have been lost, contact Alberta Education for information on school transcripts.

* Any time credit, for previous experience in the Communication Electrician trade, should be discussed with the employer and requested on the application forms by the employer.

* A contract of apprenticeship is entered into between the apprentice and the employer and should be signed within three months after the apprentice applications have been approved. If contracts have not been issued within this time, contact the Apprenticeship and Trade Certification Division.

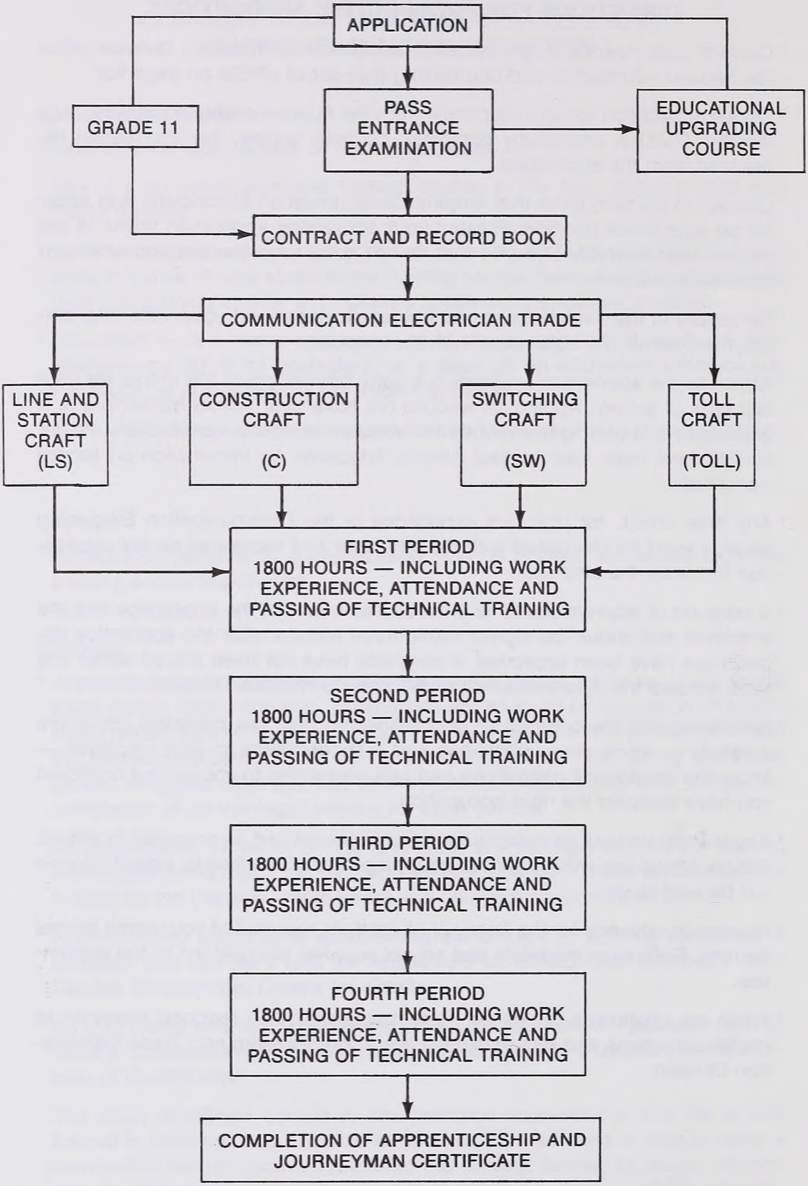
* Before signing the contract of apprenticeship read the complete document carefully — know your obligations and responsibilities to your employer — know the employer's obligations and responsibilities to you — feel confident you have selected the right occupation.

* Know when you will be expected to attend classes and be prepared to attend. School schedules will be sent to your employer and notice to attend classes will be sent to you.

* Prepare in advance for the financial obligations required of you during school training. Reference materials and school supplies are paid for by the apprentice.

* While an apprentice, it will be your responsibility to respond promptly to mailed directions and requests from the Apprenticeship and Trade Certification Division.

APPRENTICESHIP ROUTE TOWARD CERTIFICATION


APPLICATION
GRADE 11
PASS ENTRANCE EXAMINATION
EDUCATIONAL UPGRADING COURSE
CONTRACT AND RECORD BOOK
COMMUNICATION ELECTRICIAN TRADE
LINE AND STATION CRAFT (LS)
CONSTRUCTION CRAFT (C)
SWITCHING CRAFT (SW)
TOLL CRAFT (TOLL)
FIRST PERIOD 1800 HOURS — INCLUDING WORK EXPERIENCE, ATTENDANCE AND PASSING OF TECHNICAL TRAINING
SECOND PERIOD 1800 HOURS — INCLUDING WORK EXPERIENCE, ATTENDANCE AND PASSING OF TECHNICAL TRAINING
THIRD PERIOD 1800 HOURS — INCLUDING WORK EXPERIENCE, ATTENDANCE AND PASSING OF TECHNICAL TRAINING
FOURTH PERIOD 1800 HOURS — INCLUDING WORK EXPERIENCE, ATTENDANCE AND PASSING OF TECHNICAL TRAINING
COMPLETION OF APPRENTICESHIP AND JOURNEYMAN CERTIFICATE

APPRENTICESHIP COMMITTEE STRUCTURE

Communication Electrician Provincial Apprenticeship Committee

The Provincial Apprenticeship Committee for the Communication Electrician Trade is comprised of members from Local Apprenticeship Committees from the cities of Edmonton and Calgary.

This Committee is concerned with the policies that guide the program and make recommendations to the Apprenticeship and Trade Certification Board and the Executive Director of the Apprenticeship and Trade Certification Division in the following areas:

- * Contribute current information relative to changes in the trade and requirements of industry.
- * Make recommendations for changes to existing trade regulations.
- * Assist in updating of the training program through recommendations for revisions to the course outline and attendant examinations.
- * Naming personnel to Technical Advisory Committees.

Apprenticeship Committee Members:

Mr. D. Ashton — Calgary — Employee
Mr. R. Flack — Calgary — Employee
Mr. C. Barry — Edmonton — Employer
Mr. R. Hoy — Edmonton — Employer
Mr. L. Kelly — Edmonton — Employee
Mr. A. Hayduk — Edmonton — Employer
Mr. M. Grabia — Edmonton — Employee
Mr. R. Graff — Edmonton — Employer
Mr. W. Robbins — Edmonton — Employer (Alternate)

COMMUNICATION ELECTRICIAN PROGRAM
TOLL CRAFT
COURSE OUTLINE

This outline has been prepared in accordance with recommendations from the Provincial Apprenticeship Committee for the Communication Electrician Trade in the Province of Alberta.

The outline was updated following consideration given to recommendations and suggestions from:

The Provincial Apprenticeship Committee
The Technical Advisory Committee
Representatives from Training Institutes
Individuals from the Telecommunication Industry

PROCEDURES FOR RECOMMENDING REVISION(S) TO THE COURSE OUTLINE

Any concerned citizen or group in the Province of Alberta may make recommendations for change by writing to the Apprenticeship and Trade Certification Division, Edmonton.

It is requested that recommendations for change refer to specific areas and state references used. Recommendations received will be placed before regular meetings of the Provincial Apprenticeship Committee.

SAFETY EDUCATION

Safe working procedures and conditions, accident prevention and the preservation of health is of primary importance in the Apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of the government, employers, employees and the general public. Therefore, it is imperative that all parties become aware of circumstances that may lead to injury or harm and that safe learning experiences and environment can be created by controlling the variables and behaviors that may contribute to or cause an accident and/or an injury.

It is generally recognized that a safe attitude contributes to an accident free environment. As a result a healthy safe attitude towards accident prevention will benefit an employee by helping to avoid injury, loss of time and loss of pay.

A tradesman is possibly exposed to more hazards than any other person in the work force and therefore, should be familiar with the Occupational Health and Safety Act and Regulations dealing with his own personal safety and the special safety rules applying to each job.

LEGAL AND ADMINISTRATIVE ASPECTS

Employer's Responsibilities:

Accident prevention and the provisions of safe working conditions are the responsibilities of an employer. The company is responsible for:

1. The provision and maintenance of safety equipment
2. The provision of protective devices and clothing (as required by the Occupational Health & Safety Act, General Safety Regulations)
3. The enforcement of safe working procedures
4. Adequate safeguards for machinery, equipment and tools
5. Observance of all accident prevention regulations
6. Adequate training to allow a worker to use or operate equipment in an effective and safe manner.

Government's Responsibilities:

The Apprenticeship and Trade Certification Division in conjunction with the respective Provincial Apprenticeship Committee assumes the responsibility to assure that adequate safety is reflected in the curriculum and that adequate safety instruction is presented at the training establishments.

The Occupational Health and Safety Inspection Branch assumes the responsibility for periodic inspection of the operation to ensure that regulations for industry are being correctly observed.

Individual's Responsibilities:

The employee is responsible for:

1. Knowing and working in accordance with the safety regulations pertaining to job environment and
2. Working in such a way as not to endanger himself or his fellow employees

The major factor in safety is the individual employee, his personal attitude toward safety and having an awareness of the respective safety regulation.

TOLL CRAFT PROGRAM

Subjects and Time Distribution

First Period	**6 Weeks**	**30 Hours Per Week**	**180 Hours**	**Page**
Section One:	Basic Electricity — Theory		84	9
Section Two:	Basic Electricity — Lab		54	14
Section Three:	Trade Mathematics		42	18
Second Period	**6 Weeks**	**30 Hours Per Week**	**180 Hours**	**Page**
Section One:	Electronic Theory		54	21
Section Two:	Electronic Lab		18	23
Section Three:	Transmission Theory		60	24
Section Four:	Transmission Lab		24	28
Section Five:	Applied Mathematics		24	28
Third Period	**6 Weeks**	**30 Hours Per Week**	**180 Hours**	**Page**
Section One:	Analog Multiplexing — Theory and Lab		84	31
Section Two:	Digital Multiplexing — Theory and Lab		48	36
Section Three:	Logic Theory		24	40
Section Four:	Logic Lab		24	41
Fourth Period	**6 Weeks**	**30 Hours Per Week**	**180 Hours**	**Page**
Section One:	RF Transmission — Theory and Lab		138	42
Section Two:	Data Transmission — Theory and Lab		42	50

FIRST PERIOD TECHNICAL TRAINING

SECTION ONE: BASIC ELECTRICITY — THEORY 84 Hours

A. Fundamental Concepts of Electricity 8 Hours

1. Introduction to electricity
    - (a) development
    - (b) fundamental concepts and application
    - (c) components
    - (d) terminology
2. Negative and positive polarities
3. Electrons and protons in atoms
4. Unit of charge — coulomb
5. Unit of potential — volt
6. Charge in motion — current
7. Opposition to current — resistance
8. Conductance
9. Closed circuit
10. Sources of electricity

B. Ohm's Law 2 Hours

1. Definition in terms of E, I and R
2. Relationship of E, I and R to solve problems
3. Power and power dissipation in resistance
4. Multiple and submultiple units
5. Electric shock

C. DC Circuits 4 Hours

1. Series
    - (a) current
    - (b) resistance
    - (c) voltage drops
    - (d) power in series circuit
    - (e) equivalent circuits
    - (f) analysis
    - (g) effects of open and short circuits
2. Parallel
    - (a) common voltage
    - (b) branch currents
    - (c) total current

    - (d) total resistance
    - (e) conductance in parallel
    - (f) power in parallel circuits
    - (g) drawing parallel circuits
    - (h) analysis
    - (i) equivalent circuits
    - (j) effects of open and short circuits

3. Series — Parallel
    - (a) calculate total resistance
    - (b) current division
    - (c) voltage division
    - (d) total power
    - (e) analysis of series-parallel circuits
    - (f) equivalent circuits
    - (g) wheatstone bridge
    - (h) Kirchoff's laws
    - (i) calculate voltage to reference points
    - (j) open and short circuits

D. Direct Current Meters **8 Hours**

1. Types
2. Construction
3. Measurement of current
4. Meter shunts
5. Voltmeters
6. Ohmmeters
7. Multimeters
8. Meter application

E. Conductors and Insulators **2 Hours**

1. Purpose
2. Types
3. Standard wire gauge sizes
4. Hardware
    - (a) switches
    - (b) fuses
    - (c) pilot lamps, etc.
5. Wire resistance
6. Temperature coefficients
7. Ion current

8. Electron and hole charges in semi-conductors
9. Insulators

F. Resistors **2 Hours**

1. Types
2. Application
3. Color coding
4. Power rating
5. Tolerance
6. Selection for circuits
7. Resistor troubles

G. Batteries **4 Hours**

1. Function
2. Voltaic cell
3. Dry cell
4. Lead-acid cell
5. Specific gravity
6. Other cells
7. Internal resistance of batteries
8. Internal resistance of generators
9. Matching load resistance to generator

H. Magnetism **6 Hours**

1. The magnetic field
2. Magnetic flux
3. Flux density
4. Induction
5. Air gap
6. Types of magnets
7. Shielding
8. Permeability
9. Magnetic units
   (a) ampere — turns
   (b) field intensity

    (c) Ohm's law of magnetic circuits
    (d) hysteresis

I. Electromagnetic Induction **4 Hours**

1. Magnetic field around a conductor of current
2. Coil polarity
3. Motor action
4. Induced current
5. Lenz's law
6. Induced voltage
7. Faraday's law

J. Alternating Current and Voltage **8 Hours**

1. Alternating voltage generator
2. Sine wave
3. Voltage and current values for sine wave
4. Frequency
5. Period
6. Wave length
7. Phase angle
8. Time period of sine waves
9. Resistive AC circuits
10. 60 Hz line
11. Motors and generators
12. Nonsinusoidal waveforms
13. Harmonics

K. Inductance, Inductive Reactance and Inductive Circuits **12 Hours**

1. Induction by AC
2. Self-inductance
3. Self-induced voltage
4. How E_L opposes changes in current
5. Mutual inductance
6. Transformers
    (a) types of cores
    (b) core losses
    (c) types of transformers

7. Variable inductance
8. Coils in series and parallel
9. Stray inductance
10. Trouble in coils
11. Effect of E_L
12. $X_L = 2\pi fL$
13. Inductors in series and parallel
14. Ohm's law applied to X_L
15. Application of X_L
16. Waveshape of E_L induced by sine wave current
17. E leads I by 90°
18. Resistance and reactance in series
19. Resistance and reactance in parallel
20. Quality of coils
21. AF and RF chokes
22. L/R time constant
23. High voltage produced by opening RL circuits
24. Comparison of resistance, inductive reactance and impedance

L. Capacitance, Capacitive Reactance and Capacitive Circuits 12 Hours

1. Storage of charge
2. Charge and discharge of capacitors
3. Unit of capacitance
4. Typical capacitors
5. Color coding
6. Capacitors in series and parallel
7. Stray capacitance
8. Troubles in capacitors
9. Energy in electrostatic field of capacitance
10. How AC voltage produces AC current in capacitive circuits
11. $X_C = \dfrac{1}{2\pi fC}$
12. X_C in series and parallel

13. Ohm's law applied to X_C
14. Application of capacitive reactance
15. Charge and discharge current
16. I leads E by 90°
17. X_C in series and parallel circuits
18. Capacitive voltage dividers
19. Coupling capacitors
20. RC time constant
    (a) long
    (b) short
21. Universal time constant

M. Alternating Current Circuits **6 Hours**

1. AC resistive circuits
2. AC inductive circuits
3. AC capacitive circuits
4. Opposite reactances
5. Reactances and resistance in
   (a) series
   (b) parallel
6. Real and apparent power

N. Resonance **6 Hours**

1. The effect
2. Series resonance
3. Parallel resonance
4. Calculating frequency of resonance
5. Q — magnification
6. Bandwidth
7. Tuning and mistuning
8. Analysis of parallel resonant circuits
9. Damping of parallel resonant circuits
10. Choosing L and C for resonant circuits

SECTION TWO: BASIC ELECTRICITY — LAB 54 Hours

GENERAL OBJECTIVES:

1. To assist an apprentice in acquiring fundamental skills in proper and safe use of electrical bench equipment including test instruments by carrying out well planned shop activities.

2. To develop a basic understanding of d-c and a-c electric circuits and components.
3. To reinforce theoretical instruction by enabling the apprentice to gain practical circuit knowledge by performing meaningful assigned experiments.

A. Orientation

1. Laboratory rules and procedures
2. Bench kits and tools
3. Safety
4. Basic components and their symbols
5. Standard resistor color code
6. Schematic diagrams

B. Meters

1. Proper use and care
    - (a) function and range switches
    - (b) reading on different ranges
    - (c) meter errors
    - (d) safety precautions
2. Power supplies
    - (a) operation
    - (b) measuring terminal voltage

C. The Series Circuit

1. Line current
2. Voltage and voltage drop
3. Total resistance and total power
4. Application of Ohm's and Kirchoff's laws

D. Parallel Circuits

1. Total resistance
2. Line current
3. Branch current
4. Voltage and voltage drop
5. Power and resistance characteristics
6. Application of Ohm's and Kirchoff's laws

E. Series — Parallel Circuits

1. Current
    - (a) total

    - (b) branch
2. Voltage
    - (a) applied and across each branch
    - (b) across each component
3. Total resistance and total power
4. Checking resistors for open

F. Voltage Dividers

1. Characteristics
    - (a) loaded
    - (b) unloaded

G. Cells

1. Series
    - (a) opposing
    - (b) aiding
2. Parallel
3. Series — parallel
4. Care and application

H. Power Supplies

1. Internal resistance
2. Circuit efficiency
3. Maximum power transfer
4. Application

I. Wheatstone Bridge

1. Characteristics
2. Application

J. Meter Construction

1. Meter movement
    - (a) arrangement
    - (b) sensitivity
    - (c) internal resistance
    - (d) application
2. Ammeter shunts
3. Voltmeter multipliers
4. Ohmmeters
5. Multimeters

K. Oscilloscope

1. Function, use and care
2. Operation
3. Application
   (a) measuring voltage
   (b) time
   (c) measuring frequency
   (d) phase measurement

L. Alternating Current and Voltage

1. Sine wave
   (a) peak value
   (b) RMS value
   (c) cycle
   (d) frequency
   (e) wavelength
2. Angular measurement
3. Radian measure
4. Phase angle

M. Inductance (Coils) and Inductive Reactance

1. Effect of inductance on current in DC and AC circuits
2. Measurement of X_L
3. Verify that $X_L = 2 \pi fL$
4. Back EMF
5. Phase relations between I and E inductive circuits
6. Open coil
7. Resistance of coil
8. L/R time constant

N. Capacitors, Capacitance and Capacitive Reactance

1. Determining value of capacitors
2. Effect of capacitance on current in DC and AC circuits
3. Measurement of X_c
4. Verify that $X_c = \frac{1}{2 \pi fc}$
5. Phase relations between I and E in capacitive circuits
6. RC time constant

7. Capacitors in series and parallel

8. Open and shorted capacitors

O. Series RLC Circuits

1. Current and voltage

2. Verify the $Z = \sqrt{R^2 + (X_L - X_C)^2}$

3. Series resonance
   - (a) $fr = \dfrac{1}{2\pi\sqrt{LC}}$
   - (b) line current
   - (c) impedance and voltage
   - (d) other characteristics
   - (e) application

P. Paralleled RLC Circuits

1. Current and voltage

2. Impedance (Z)

3. Parallel resonance
   - (a) line current
   - (b) impedance and voltage
   - (c) other characteristics
   - (d) application

SECTION THREE: TRADE MATHEMATICS 42 Hours

A. Review of Basic Arithmetic

1. Common fractions

2. Decimal fractions

3. Percentage

4. Factoring

5. Ratio and proportion

B. D.C. Series Circuit Problems

1. Power of ten
   - (a) scientific notation
     - (i) multiply
     - (ii) divide
     - (iii) raise to a power
     - (iv) add and subtract
   - (b) electronic calculator
     - (i) proper use

2. $E = IR$ and its variations

3. P = IE and its variations
4. Formula manipulation
5. Multi-resistor series circuits
6. Internal source resistance

C. D.C. Parallel and Series-Parallel Circuit Problems

1. Parallel circuits
   (a) application of Ohm's and Kirchoff's laws
   (b) power calculations
2. Series — Parallel circuits
   (a) application of Ohm's law
   (b) power calculations
3. Voltage divider problems
4. Wheatstone bridge problems

D. Trigonometric Functions

1. Properties of a right angle triangle
2. Trigonometric ratios
   (a) sine
   (b) cosine
   (c) tangent
3. Solution of right angle triangles
4. Trigonometric solution of A.C. circuits
   (a) voltage
   (b) current
   (c) phase angle
   (d) power
   (e) impedance

E. Series AC Circuit Problems

1. Resistive
2. Inductive
3. Capacitive
4. RL, RC and LRC
5. Power
6. Resonance

F. Parallel AC Circuit Problems

1. Resistive
2. Inductive

3. Capacitive
4. RL, RC and LRC
5. Power
6. Resonance

SECOND PERIOD TECHNICAL TRAINING

SECTION ONE: ELECTRONIC THEORY 54 Hours

A. Review of Prerequisites 4 Hours

1. Ohm's law
2. Impedance R, X_L
3. Current and voltage sources
4. Thevenin's theorem

B. Semi-Conductor Physics

1. Atomic structure of atoms
2. Crystals
3. Doping

C. PN Junction

1. Forward bias
2. Reverse bias
3. Leakage current

D. Diodes 8 Hours

1. The rectifier diode
2. Diode curve
3. Bulk resistance
4. Reverse resistance
5. Zener diode
6. Breakdown voltage and peak inverse voltage

E. Power Supplies (Block Diagrams)

1. Rectifiers
2. Filters
3. Voltage regulators

F. Junction Transistors 5 Hours

1. Transistor theory and correct biasing
2. Symbols

3. Current relationship
    - (a) alpha
    - (b) beta
4. Cut off current, breakdown voltage and collector saturation voltage

G. Transistor Biasing **9 Hours**

1. Base bias
2. Emitter bias
3. Collector feedback bias
4. Collector cutoff current

H. Small Signal Amplifiers **8 Hours**

1. Current gain and voltage gain of amplifiers
2. Base driven amplifiers
3. Emitter driven amplifiers
4. Comparisons between the three types of configurations
    - (a) common emitter (CE)
    - (b) common collector (CC)
    - (c) common base (CB)

I. Power Amplifiers **6 Hours**

1. Operating point
2. Single ended power amplifier
3. Push-pull amplifier

J. Oscillators **2 Hours**

1. Theory of operation
2. Types of oscillators
    - (a) RC phase shift
    - (b) wien-bridge
    - (c) Hartley
    - (d) Colpitts
    - (e) crystal

K. Metal-Oxide Semiconductor Fet (Mosfet) **3 Hours**

1. Construction
2. Operation
3. Application, e.g. common source amplifier

L. IC Operational Amplifier **8 Hours**

1. Integrated circuit PNP and NPN transistors
2. Dual transistors
3. Differential amplifiers
4. Ideal operational amplifiers
5. Analysis of operational ampliers
6. Circuits (block diagrams)
    (a) the comparator
    (b) the voltage follower
    (c) inverting amplifier
    (d) the non-inverting amplifier
    (e) the summing amplifier
    (f) the subtracting amplifier
    (g) the active filter

M. Clipping Circuits **1 Hour**

1. Diode clipper
2. Transistor clipper

SECTION TWO: ELECTRONIC LAB 18 Hours

A. Lab Familiarization Activities **1 Hour**

1. Orientation
2. Procedures
3. Proper use of test equipment
4. Safety

B. Power Supplies **5 Hours**

1. Construction of a full wave power supply with various types of filters and using zener diodes for regulation
2. Measuring DC output and ripple
3. Relating lab observations to theoretical explanations

C. Transistor Circuit Familiarization **2 Hours**

1. Recognizing different transistor biasing arrangements
2. Perform “Go-No-Go” checks on the transistor using VOM
3. Determining whether a transistor is NPN or PNP using a VOM
4. Identifying transistor terminals using a VOM

D. Common Emitter Amplifier 4 Hours

1. Measuring voltage gain
2. Phase relations between input and output voltages
3. Measuring input and output impedance
4. Troubleshooting common emitter amplifiers by comparing calculated and measured values

E. Oscillator Circuits 2 Hours

1. Construction of an oscillator circuit
2. Calculation and measurement of oscillator frequency

F. Operational Amplifiers 4 Hours

1. Construct an operational amplifier
2. Calculate and measure the gain of an operational amplifier
3. Study feedback effect
4. RC active filter

SECTION THREE: TRANSMISSION THEORY 60 Hours

A. General Toll Switching Plan 1 Hour

1. Office classifications
2. Homing arrangements
3. Control switching points
4. High usage trunks
5. Alternate routing

B. Block Diagram of a Typical DDD Call Over a Multiplex System (Overview) 5 Hours

1. Interfacing
    - (a) sunscribers telephone set
    - (b) subscribers loop
    - (c) CO exchange
    - (d) trunk cable
    - (e) CO toll switching
    - (f) CO secondary board
    - (g) office cable
    - (h) CO toll carrier terminal (Max.)
    - (i) toll carrier facility
        - (i) paired cable

    - (ii) co-ax
    - (iii) microwave
  - (j) carrier repeaters and descending order of the above

C. Transmission of Intelligence 6 Hours

1. Voice
   - (a) charateristics of speech
   - (b) basic requirements for a voice transmission system
2. Data and telegraph
   - (a) characteristics of data and telegraph signals
   - (b) basic requirements for a data or telegraph transmission system
3. Music
   - (a) characteristics of musical sounds
   - (b) basic requirements for program transmission
4. Television
   - (a) characteristics of video signals
   - (b) basic requirements for a television transmission system

D. Voice Transmission Impairments 3 Hours

1. Loss
2. Amplitude and frequency distortion
3. Noise
   - (a) steady state
   - (b) impulse
   - (c) crosstalk

E. Power Levels

- (a) dB — power ratio
- (b) dB — voltage ratio
- (c) dBm — decibels relative to a reference
- (d) conversions
  - (i) dBm to watts
  - (ii) watts to dBm
- (e) meter correction factors
- (f) TLP
- (g) dBm0

F. Pads and Attenuators

1. Characteristics impedance of networks
2. Characteristics of a "T" section
   - (a) design considerations
     - (i) formulas
     - (ii) development of pad factors
     - (iii) loss and impedance

3. Characteristics of π, H, L and square pads
    - (a) purpose
    - (b) design formulas using pad factors

G. Elementary Theory of Transmission Lines — 4 Hours

1. Primary constants
    - (a) effects on Zo
    - (b) effects on attenuation

2. Electromagnetic waves
    - (a) physical conception
    - (b) wave length
    - (c) velocity of propagation — Terminology

3. Characteristic impedance
    - (a) effect of terminating a line in its Zo
    - (b) impedance mismatch
    - (c) reflection
        - (i) return loss

4. Attenuation

5. Coaxial cable
    - (a) radiation resistance — definition
    - (b) confining a field
    - (c) Zo knowing d1 and d2

H. Noise — 6 Hours

8. Definition

2. Sources of noise

3. Effect of temperature

4. Noise figure

5. Noise measurement
    - (a) dBrNC
    - (b) dBrNCO
    - (c) PWP

6. Noise weighting networks

I. Interoffice Transmission Considerations — 6 Hours

1. Intertoll trunk design factors
    - (a) design factors
        - (i) echo
        - (ii) tolerance to echo
        - (iii) singing
        - (iv) noise and crosstalk
    - (b) 2-wire/4-wire switching

(c) office balance
(i) through balance
(ii) terminal balance

2. Customer loop design factors
   (a) loss limits
   (b) signalling limits

J. Hybrids **3 Hours**

1. Purpose

2. Functional description

3. Parameters
   (a) purpose
   (b) principle of operation

K. Basic Telephone Set **4 Hours**

1. Basic components, their symbols and theory of operation
   (a) transmitter
   (b) receiver
   (c) dial
   (d) hookswitch
   (e) ringer and capacitor
   (i) metallic
   (ii) grounded
   (f) network
   (i) sidetone
   (ii) anti-sidetone
   (g) terminals

L. Echo Suppressors **2 Hours**

1. Purpose

2. Principle of operation

M. Filters **2 Hours**

1. Types
   (a) high pass
   (b) low pass
   (c) band pass
   (d) band stop

2. Purpose and use

n. Equalizers **1 Hour**

1. Purpose

2. Types
    - (a) attenuation
    - (b) phase

O. Cable Loading **3 Hours**

1. Purpose
    - (a) effect on frequency spectrum
    - (b) effect on propagation
2. Loading schemes

P. Compandors **2 Hours**

1. Purpose

SECTION FOUR: TRANSMISSION LAB 24 Hours

A. Decibels

B. DDD Calls Over Multiplex Systems

C. Transmission Lines

1. Primary constants
2. Electromagnetic waves
3. Characteristic impedance
4. Attenuation
5. Radiation resistance

D. Pads and Attenuators

E. Filters

F. Cable Loading

SECTION FIVE: APPLIED MATHEMATICS 24 Hours

A. Logarithms

1. Definitions
2. Notation
3. Rules of logarithms
4. Common logarithms
5. Arithmetical operations using logarithms
    - (a) multiplication

   - (b) division
   - (c) raising to a power
   - (d) finding roots

6. Logarithms and exponential equations

7. Graphs of exponential and logarithmic factors

8. Use of log graph paper

B. Review

1. Algebra

2. Kirchoff's laws

3. How to use the calculator

4. Ohm's law

5. AC circuits

6. Series and parallel

C. Exponents and Radicals

1. Fundamental laws of exponents
   - (a) zero exponent
   - (b) negative exponent
   - (c) fractional exponent

2. Radicals
   - (a) simplifications
   - (b) removing factors
   - (c) simplifying radicals with fractions
   - (d) simplifying by removing factors from the radicals
   - (e) addition and subtraction
   - (f) mutiplication and division
   - (g) square roots of negative numbers

D. Trigonometric Functions

1. Trigonometric ratios of acute angles

2. Reciprocal relations of the functions

3. Functions of complimentary angles

4. Functions of any angle

5. Solution of right triangles
   - (a) facts concerning "right triangles"
   - (b) procedure for solution of "right triangles"
   - (c) terms relating to miscellaneous trigonometric problems

E. Operator “J”

1. Real Numbers
2. Imaginary numbers
3. Complex numbers
4. Graphical representation of imaginary numbers
5. Polar to rectangular conversion
6. Application to AC circuits

THIRD PERIOD TECHNICAL TRAINING

SECTION ONE: ANALOG MULTIPLEXING 84 Hours

Theory — 60 Hours — Lab — 24 Hours

A. Introduction to Multiplexing

1. Definition
2. Purpose
3. Types of multiplexing systems
   (a) frequency division multiplexing
      (i) definition
      (ii) principle of operation
   (b) time division multiplexing
      (i) definition
      (ii) principle of operation

B. Modulation

1. Carrier
   (a) instantaneous amplitude
   (b) characteristics of carrier which can be modulated
2. Amplitude modulation
   (a) waveform (double sideband full carrier)
   (b) modulation factor
   (c) sidebands
   (d) bandwidth requirements
3. Frequency modulation
   (a) waveform
   (b) modulation index
   (c) sidebands
   (d) BW requirement
   (e) Carson rule for BW
4. Comparison of AM and FM
   (a) bandwidth requirement
   (b) transmitted power
      (i) unmodulated
      (ii) modulated
5. Single sideband supressed carrier transmission
   (a) transmission of single sideband
   (b) intelligence in single sideband
   (c) demodulation of received single sideband

C. Block Diagram Study of a Simple Toll Circuit (Sub to Sub) 3 Hours

1. Function of each block in system
2. Function of each trunk in system

3. Types of transmission mediums used for inter-toll trunks and respective V.F. capacities
    - (a) point of point microwave
    - (b) point to point V.H.F. radio
    - (c) coaxial cable
    - (d) multiconductor cable
    - (e) open wire
    - (f) submarine cable
    - (g) fibre optics
    - (h) satellite

D. Block Diagram Study of a Frequency Division Multiplex System 3 Hours

1. Function of each block
    - (a) four wire terminating set
    - (b) transmit pad
    - (c) voice frequency filter
    - (d) modulator
    - (e) carrier supply
    - (f) transmit band pass filter
    - (g) receive band pass filter
    - (h) demodulator
    - (i) voice frequency filter
    - (j) receive pad

2. Level and impedance requirements
    - (a) review of dB, dBm and dBmO

3. 2 wire system Vs 4 wire system

E. Basic Signalling 2 Hours

1. DC signalling
    - (a) telephone loop signalling
    - (b) simplex
    - (c) duplex

2. AC signalling
    - (a) out of band signalling (SF)
    - (b) in-band signalling (SF)
    - (c) multifrequency signalling in-band
    - (d) modified out of band signalling

F. Single Frequency Signalling Unit (SF Set) 2 Hours

1. Purpose of SF set

2. Block diagram of SF set

3. Transmit functions (simplified E type block diagram)
    - (a) tone supply
    - (b) tone control circuit
    - (c) cut off circuit

    - (d) high level circuit
    - (e) VF transmit path

4. Receive functions (simplified E type block diagram)
    - (a) VF receive path
    - (b) band elimination filter
    - (c) VF amplifier
    - (d) amplitude limiter
    - (e) guard circuit
    - (f) receive relays

G. Patch Bays — 1 Hour

1. Purpose

2. Jack arrangement for 2 W

3. 2 W patch bay

4. 4 W patch bay

5. 6 W patch bay

6. Monitoring

7. Patching techniques

H. Low Capacity F.D.M. Systems — 23 Hours

1. A block diagram study of a twenty-four channel system
    - (a) carrier supply
    - (b) limiter
    - (c) VF bandpass filter
    - (d) modulator
    - (e) transmitting amplifier
    - (f) transmitting bandpass filter
    - (g) receive bandpass filter
    - (h) receive HF amplifier
    - (i) demodulator
    - (j) receive VF lowpass filter
    - (k) receive VF amplifier
    - (l) signalling M lead
    - (m) signalling M relay
    - (n) signalling slot filter
    - (o) signalling detector and devices
    - (p) signalling E relay
    - (q) E lead
    - (r) channel carrier synchronization

2. Detailed study of 4 wire terminating sets
    - (a) hybrid
    - (b) transmit and receive pads
    - (c) balance networks

- (d) NBOC
- (e) LBOC

3. Detailed study of filters
   - (a) prototypes LC filters
     - (i) low pass
     - (ii) high pass
     - (iii) bandpass
     - (iv) band elimination
   - (b) filters in parallel
     - (i) filter flanking
     - (ii) annulling networks
   - (c) crystal filters

4. Detailed study of modulator
   - (a) types
     - (i) diode balanced bridge
     - (ii) diode ring
     - (iii) transistor bridge
   - (b) principle of operation and output waveforms of each
   - (c) frequency components in modular outputs

5. Amplifiers
   - (a) distortion
   - (b) negative feedback
   - (c) temperature stabilization
   - (d) equalizing amplifiers

6. Review of pads and equalizers
   - (a) pads
     - (i) loss
     - (ii) characteristic impedance
   - (a) equalizers
     - (i) loss Vs frequency of line
     - (ii) loss Vs frequency of equalizer
     - (iii) characteristic impedance of equalizer

7. Compandors
   - (a) purpose
   - (b) location in toll circuit
   - (c) example of S/N improvement
   - (d) simplified operation

8. A detailed study of a typical low capacity system

I. Commercial F.D.M. Modulation Plans

1. Low capacity
   - (a) 45 BN
   - (b) N2

2. High capacity
   - (a) 600 channel CCITT

   - (b) 960 channel CCITT
   - (c) 600 channel L600
   - (d) 600 channel U600

J. Other Multiplex Systems Block Diagrams — 20 Hours

1. 46AC3
   - (a) review modulation plan
   - (b) 600 channel block diagram
   - (c) frequency generating equipment
2. A block diagram study of the Lenkurt 46AC3 high capacity multiplex system
   - (a) modulation plan
   - (b) channel shelf equipment
     - (i) channel units
     - (ii) carrier generation unit
     - (iii) channel carrier filter unit
     - (v) HF transmit unit
     - (vi) HF receive unit
     - (vii) band translators
     - (viii) channel power supply shelf
   - (c) primary frequency supply shelf
     - (i) line pilot filter unit
     - (ii) sync oscillator unit
     - (iii) monitor unit
     - (iv) master oscillator unit (used as standby)
     - (v) line pilot generator unit
   - (d) channel frequency generation shelf
     - (i) 8140KHZ generator unit
     - (ii) 3825HZ generator unit
   - (e) intermediate frequency generator shelf
     - (i) 12 KHZ generator unit
     - (ii) 124 KHZ generator unit
   - (f) power supply shelf
   - (g) super group equipment
     - (i) S.G. mod unit
     - (ii) S.G. summing amp
     - (iii) transmit output unit
     - (iv) receive input unit
     - (v) receive distribution amp
     - (vi) S.G. demod unit
     - (vii) S.G. receive amp
     - (viii) S.G. carrier generator units
     - (ix) alarm tone supply unit
     - (x) power regulator units
3. 45 BN
   - (a) modulation plan
   - (b) terminal block diagram
   - (c) frequency frogging repeater block diagram

4. MA4
    - (a) modulation plan
    - (b) terminal block diagram

5. N2
    - (a) modulation plan
    - (b) terminal block diagram

K. Interfacing of Multiplex Equipment to Transmission Medium — 1 Hour

1. Wire line entrance link equipment
    - (a) purpose
    - (b) location
    - (c) type A block diagram
    - (d) type B block diagram
    - (e) type AR block diagram
    - (f) type C block diagram

L. Interfacing of Multiplex to Switching Equipment — 1 Hour

1. Toll trunk
    - (a) C.D.
    - (b) S.D.
    - (c) sequence chart

SECTION TWO: DIGITAL MULTIPLEXING — 48 Hours

THEORY — 36 Hours — LAB — 12 Hours

A. Introduction to Pulse Code Modulation — 3 Hours

1. Analog vs. digital signals
    - (a) characteristics of each

2. Basic principle of time division multiplexing
    - (a) comparison with FDM

3. Pulse amplitude modulation
    - (a) sampling and sampling theorem
    - (b) PAM signal characteristics
    - (c) problems and limitations

4. Basic functions of pulse code modulation
    - (a) sampling
    - (b) quantizing
    - (c) encoding

B. Fundamentals of Pulse Code Modulation — 5 Hours

1. A simple PCM system
    - (a) Tx channel — sampling
    - (b) Tx common equipment — quantizing and encoding
    - (c) repeatered line — regeneration

    (d) Rx common equipment — decoding
    (e) Rx channel — V.F. reconstruction

2. Advantages of pulse code modulation

3. The PCM sampler

4. Quantization in PCM systems
    (a) quantizing and quantization noise
    (b) compromising between noise and bandwidth
    (c) PCM compandors
    (d) compression characteristic curve

5. The PCM encoder

6. PCM signal format
    (a) channel word interleaving
    (b) synchronization bits
    (c) PCM line rate — calculation
    (d) PCM terminal timing
    (e) unipolar to bipolar conversion — advantages

7. Zero code suppression and amplitude limiting

C. Description of D2/D3 System Parameters **6 Hours**

1. Introduction to the D2/D3 system
    (a) comparison of exchange and toll quality PCM systems

2. D2/D3 PCM frame format
    (a) 8 bit voice encoding 5 of 6 frames
    (b) signalling bits — 1 of every 6 frames
    (c) the 193rd "S" bit position

3. Signalling and framing identification
    (a) S-bit pattern — 24 channel system
    (b) sync pattern — terminal framing
    (c) signalling identification pattern
    (d) A & B signalling channels
    (e) the 12 frame "superframe"

4. D2/D3 PCM encoding methods
    (a) non-folded binary code
    (b) folded binary code
    (c) advantages of a folded binary code
    (d) conversion of an example voice sample to a binary PCM word
    (e) zero code suppression in D2/D3 PCM

5. The compression characteristic curve
    (a) compression requirements
        (i) improved S/D ratio
        (ii) constant S/D ratio over wide input range
    (b) the μ-law curve
    (c) D2/D3 CODEC ($\mu=255$)
    (d) non-uniform codec transfer characteristic

  - (e) straight line approximation of compression characteristic curve, sign-segment-step
  - (f) evaluating levels on the compression characteristic curve (examples using PAM samples)
  - (g) linearizing the PCM code

D. PCM Channel Bank

1. PCM channel units
   - (a) transmit, receive and signalling arrangements
   - (b) 2 wire/4 wire E & M

2. DSI timing
   - (a) 1.544 master oscillator
   - (b) transmit and receive digit counters
   - (c) transmit and receive channel counters

3. Receive synchronization
   - (a) receive framing logic
   - (b) receive signalling frame identification (A or B)
   - (c) out of frame detector — local alarm — waveforms
   - (d) bit 2 detector — remote alarm
   - (e) synchronization restoration

4. Terminal alarms
   - (a) local alarm: loss of PCM, synchronization or power
   - (b) remote alarm
   - (c) power alarm
   - (d) system alarm — office alarms

5. Terminal alignment test set

E. Fundamentals of T1 — repeater lines 6 Hours

1. T1 line signal characteristics
   - (a) characteristics
   - (b) advantages of bipolar transmission

2. Definition of "SPAN" and "SPAN LINE"
   - (a) through offices

3. Block diagram of PCM system
   - (a) terminal equipment
   - (b) line terminating equipment
   - (c) repeatered line equipment

4. Repeaters
   - (a) nominal repeater section loss
   - (b) line repeaters — block diagram
     - (i) reshaping (equalization) function
     - (ii) retiming function
     - (iii) regeneration function
   - (c) errors of commission and omission
   - (d) office terminating repeater units

5. Simplex powering of PCM line
    - (a) purpose
    - (b) operation
        - (i) loop current
        - (ii) repeater powering — looped or through operation
    - (c) sealing current
    - (d) simplex power unit — office

6. PCM fault locating
    - (a) concept — fault identification
    - (b) interrogation signal
        - (i) basic single interrogation method
        - (ii) looped interrogation system
        - (iii) mutiple fault pairs
        - (iv) amplifiers with fault locate filters
        - (v) office fault locate filter units
        - (vI0 line fault locate filter units
    - (c) the span and repeater test set

F. Digital Hierarchy 4 Hours

1. Introduction to hierarchy of digital signals
    - (a) DS1 — bit rate — channel capacity — multiplexing — facility
    - (b) DS2 — bit rate — channel capacity — multiplexing — facility
    - (c) DS3 — bit rate — channel capacity — multiplexing — facility
    - (d) DS4 — bit rate — channel capacity — multiplexing — facility
    - (e) DS1C — bit rate — channel capacity — multiplexing — facility
    - (f) DS3A — bit rate — channel capacity — multiplexing — facility

2. formating of digital line signals — introduction
    - (a) synchronization methods
    - (b) framing methods
    - (c) housekeeping bits
    - (d) parity checking
    - (e) control frames
    - (f) sub frames
    - (g) frames

3. Format tables
    - (a) DS1 signal format
    - (b) DS2 signal format
    - (c) DS3 signal format
    - (d) DS4 signal format

4. Characteristics of digital cross connect signals

G. Digital Coding 2 Hours

1. Types of digital codes
    - (a) non return to zero (NRZ) unipolar
    - (b) non return to zero (NRZ) bipolar
    - (c) return to zero (RTZ) unipolar
    - (d) return to zero (RTZ) bipolar

2. Digital multiplexer encoding techniques
    - (a) AM1
    - (b) B6ZS
    - (c) B3ZS
    - (d) scrambling

H. Digital Multiplexers — 2 Hours

1. Block diagram M1 — 4 mult
    - (a) M1
    - (b) M2
    - (c) M3
    - (d) Mr

SECTION THREE: LOGIC THEORY — 24 Hours

A. Number Systems

1. Study of decimal systems as an introduction to
    - (a) binary
    - (b) binary coded decimal

B. Basic Logic Circuits

1. Introduction to Boolean Algebra

2. AND, OR, NOT

3. Truth tables

4. Simple multilevel functions

5. Simple logic circuits
    - (a) AND
    - (b) NOR
    - (c) NOT
    - (d) 2/3 level

6. NAND gates

7. AND using NANDS

8. OR using NANDS

9. NOT using NANDS

10. NAND realization and multilevel functions

C. Flip Flops

1. S-R NAND circuit study

2. D type NAND circuit study

3. J-K MS1 version — external characteristics

D. Counters, Coders, Registers

1. Counters
   - (a) simple binary counter
   - (b) MS1 counter circuits
2. Encoders
   - (a) decimal to binary and BCD
   - (b) binary, BCD to decimal
   - (c) MS1 coder circuits
3. Registers
   - (a) MS1 shift register
   - (b) MS1 parallel register

E. Miscellaneous

1. Review of course content
2. Institute examinations

SECTION FOUR: LOGIC LAB 24 Hours

A. Lab Familiarization Activities

1. Orientation
2. Procedures
3. Proper use of test equipment
4. Safety, etc.

B. Combinational Circuits

1. Build several simple NAND circuits and test for operation

C. Flip Flops

1. Build and test RS and D type flip flops using NAND gates
2. Test MS1 J-K flip flop

D. MS1 Logic Chips

1. Check the operation of a counter and decoder considered in theory

E. Miscellaneous

1. Perform additional activities in the lab as may be required by the particular class
2. Institute exams

FOURTH PERIOD TECHNICAL TRAINING

SECTION ONE: RF TRANSMISSION 138 Hours
Theory - 102 Hours — Lab - 36 Hours

A. Review of Amplitude Modulation 1 Hour

1. Types
2. Products of modulation
3. Mathematics of amplitude modulation

B. Frequency Modulation 3 Hours

1. FM concepts
   - (a) deviation
   - (b) noise advantage
2. Comparison of AM and FM
   - (a) time domain
   - (b) frequency domain
3. Comparison of noise in FM and PM
   - (a) pre-emphasis
   - (b) de-emphasis

C. Transmission Lines 3 Hours

1. Review
   - (a) wave propagation along lines
   - (b) lines with reflections
2. Transmission line applications
3. Introduction to waveguides

D. Antennas and Propagation 4 Hours

1. Basic antenna principles
2. Basic antennas
3. Methods of feeding antennas
4. Directional antenna systems
5. Wave propagation

E. Waveguides 4 Hours

1. Theory of propagation
   - (a) modes of operation
2. Types of waveguide
   - (a) dominant mode
   - (b) loss

    - (c) comparison of advantages
    - (d) bends and twists

F. Waveguide Components 4 Hours

1. Resonant cavities and filters
2. Tees and couplers
3. Transducers
4. Impedance matching devices
5. Isolators
6. Circulators
7. Matched loads

G. Amplifier Coupling Circuits 2 Hours

1. Types of couplings
2. Types and characteristics of inductively coupled circuits
3. RF filter circuits
4. Impedance matched by coupled circuits

H. RF Voltage Amplifiers 2 Hours

1. Impedance coupled RF amplifiers
2. Single tuned transformer coupled RF amplifiers
3. Double tuned transformer coupled RF amplifiers
4. High frequency circuits
5. Solid state RF amplifiers

I. RF Power Amplifiers 1 Hour

1. Class "C" amplifiers
2. Neutralization in class "C" amplifiers
3. Class "B" linear amplifiers
4. Transistor RF power amplifiers

J. Microwave Devices 4 Hours

1. Microwave power amplifier tubes
    - (a) klystrons
    - (b) travelling wave tubes
2. Solid state microwave devices
    - (a) power amplifiers
    - (b) gunn diodes

3. Mixers
4. Detectors

K. Types of Mobile Radio Sysytems **20 Hours**

1. General mobile
2. Private systems
   - (a) AGTL
   - (b) DOH
   - (c) forestry
3. Point to point
   - (a) VHF
   - (b) UHF

L. Methods of Operation

1. Simplex
2. Duplex
3. Repeater

M. DOC Specifications

1. VHF and UHF
   - (a) frequency spectrum
   - (b) operating range
   - (c) channel spacing

N. Typical System Components

1. Base station
   - (a) transmitter
   - (b) receiver
   - (c) antenna
   - (d) power supply (AC)
   - (e) controls (auxiliary units)
2. Mobile unit
   - (a) transmitter
   - (b) receiver
   - (c) antenna
   - (d) control head
   - (e) power supply (DC)
   - (f) frequency selection device

O. Special Features

1. Remote control (base station)
2. Signalling
   - (a) general mobile

  - (b) private system
  - (c) dial converter

P. Block Diagram Analysis

1. Basic transmitter
   - (a) crystal oscillator
   - (b) audio amplifier
   - (c) clipper and amplifier
   - (d) deviation control
   - (e) phase modulator
   - (f) buffer amplifier
   - (g) multipliers
   - (h) driver
   - (i) power amplifier
   - (j) channel switching
2. Receiver
   - (a) RF amplifiers
   - (b) first oscillator
   - (c) first mixer
   - (d) first IF amplifier
   - (e) second oscillator
   - (f) second mixer
   - (g) second IF filter
   - (h) second IF amplifier
   - (i) limiter
   - (j) discriminator
   - (k) audio amplifier
   - (l) squelch circuit
   - (m) channel switching

Q. Antennas and Associated RF Transmission Components

1. Basic antenna principles
2. Antenna variations
3. Combining radios on one antenna (duplexer)
4. Switching
   - (a) antenna c/o relay
   - (b) diode switch

R. Manufacturers

1. General comparison of mobile radio products
   - (a) Motorola
   - (b) Pye
   - (c) Systcom
   - (d) General Electric
     - (i) public base station
     - (ii) private mobile

S. Operating Procedures and Servicing

1. Operating procedures and precautions
2. Test equipment — types and functions
   - (a) spectrum analyzer
   - (b) transmission test set
   - (c) RF power meter
   - (d) probe
   - (e) communications monitor (Cushman)
   - (f) oscilloscope (storage)
3. Transmitter tuning
4. Receiver alignment
5. Trouble testing
   - (a) stage gains
   - (b) fault location
   - (c) RF interference

T. Basic Concepts of Microwave — 3 Hours

1. Frequency spectrum
2. Advantages of microwave communication
3. Other applications of microwave

U. Propagation at Microwave Frequencies — 3 Hours

1. Transmission paths between two antennas
2. Free space path loss
3. Antenna heights and path clearance
4. Fading
5. Absorption
6. Diversity and protection

V. Microwave Antennas — 2 Hours

1. Types
2. Antenna characteristics
3. Pressurization

W. Microwave Frequency Allocations — 2 Hours

1. DOC plans
2. 4 Ghz 2 frequency plan

X. Channel Separation Networks — 1 Hour

1. Hybrid type
2. Circulator type

Y. Types of Microwave Systems — 1 Hour

1. IF heterodyne
2. Baseband remodulating
3. Digital microwave

Z. Block Diagram Study of an IF Heterodyne System — 4 Hours

1. FM modulator
2. FM demodulator
3. IF section
4. RF section
5. Repeater

AA. Microwave Transmission Impairments — 4 Hours

1. Noise
   (a) idle
   (b) intermodulation
2. Phase and delay
   (a) group delay
   (b) absolute delay
   (c) differential phase
3. Amplitude distortion
   (a) linearity
   (b) frequency response
   (c) differential gain

BB. Detailed Block Diagram Study of the RA3-T4 — 3 Hours

1. Functional description of
   (a) mixer
   (b) microwave generator
   (c) IF pre-amp
   (d) group delay equalizers
   (e) IF main amplifier
   (f) IF post amplifier
   (g) squelch unit
   (h) buffer amplifier
   (i) up-converter
   (j) travelling wave tube
   (k) circulators and isolators

   - (l) terminal configuration
   - (m) repeater configuration

CC. Detailed Block Diagram Study of the SS2000 (Lenkurt 71-F2) **3 Hours**

1. Functional description of
   - (a) baseband amplifier
   - (b) oscillator modulator
   - (c) power amplifier
   - (d) multiplier — filter
   - (e) AFC arrangement
   - (f) mixer pre-amp
   - (g) IF amplifier
   - (h) limiter filter
   - (i) demodulator
   - (j) local oscillator
   - (k) alarms and muting

DD. General Discussion and Comparison of Microwave Systems **2 Hours**

1. Northern Telecom
   - (a) TD2
   - (b) RA1
   - (c) RA2B
   - (d) RA3-T4

2. Lenkurt
   - (a) CTR — 108, 75A
   - (b) MM 600

EE. Digital Microwave Radio **10 Hours**

1. Modulation techniques
   - (a) QPSK
   - (b) 8PSK
   - (c) QPSR

2. N/T DRS-8 system
   - (a) MR-3A muldem
   - (b) CE-4 protection
   - (c) RD-3 microwave radio

3. Propagation and measurement concepts

FF. Fibre Optic Transmission Systems **10 Hours**

1. Terminology
   - (a) refractive index
   - (b) numerical aperture
   - (c) acceptance angle
   - (d) contrast

    - (e) modal dispersion
    - (f) chromatic distortion
    - (g) spectral purity
    - (h) responsitivity

2. Fiber characteristics
    - (a) propagation
    - (b) types
    - (c) pulse spreading
    - (d) manufacturer's specifications

3. Light sources
    - (a) types
    - (b) manufacturer's specifications

4. Photo detectors
    - (a) types
    - (b) manufacturer's specifications

5. Electronic interfacing
    - (a) drivers (discrete types)
    - (b) preamps (discrete types)

6. Splices and connectorization

7. Cable types

8. System engineering
    - (a) link loss budget
    - (b) link risetime budget

GG. Satellite Communications **6 Hours**

1. Introduction

2. Satellite link (typical)
    - (a) uplink
        - (i) transmitter and antenna
        - (ii) propagation path
    - (b) downlink
        - (i) receiver and antenna
    - (c) noise power and S/N ratio
    - (d) satellite components
        - (i) transponders
        - (ii) power

3. Receiving stations
    - (a) block diagram
    - (b) noise temperatures
    - (c) LNA
    - (d) receivers
    - (e) link performance

4. Satellites
    (a) Anik series
        (i) specifications
        (ii) footprints
    (b) life time and orbit schedules

5. Frequency plans
    (a) 6/4 GHz
    (b) 14/12 GHz
    (c) other

6. Bandwidth, data rates and information capacity

7. Modulation formats and access techniques
    (a) FM
    (b) FDM
    (c) FDMA
    (d) SCPC
    (e) DAMA
    (f) TDMA

8. Future of satellite systems

SECTION TWO: DATA TRANSMISSION 42 Hours

Theory - 30 Hours — Lab - 12 Hours

A. A Basic Data Communications System

1. Data source — computer

2. Data encoder — modern transmitter

3. Communications channel — telecommunications facility

4. Data encoder — modern receiver

5. Data sink — data terminal

B. Communications Coding Structures

1. Analog and digital data
    (a) analog data; analog transmission
    (b) digital data; digital transmission

2. Types of data codes
    (a) binary coded decimal (BCD)
    (b) excess-3 code
    (c) biquinary code
    (d) reflected (gray) code

3. Baudot code
    (a) asynchronous and synchronous data transmission
    (b) bit rate and baud rate

4. ASCII code
    - (a) parity bits

5. EBCDIC code

6. Methods of error detection
    - (a) vertical redundancy check
    - (b) horizontal redundancy check
    - (c) cyclic redundancy check

C. Electrical Characteristics of Digital Signals

1. Binary digital signals
    - (a) time domain
    - (b) frequency domain
    - (c) analysis of rectangular waves
        - (i) spectrum analysis
        - (ii) harmonic nulling factor
    - (d) Nyquist theorem applied to data

2. Mutilevel signals
    - (a) time domain
    - (b) frequency domain
    - (c) increasing data bit rate without increasing baud rate using multilevel signals
    - (d) Shannon's theorem of data capacity in noisy environments
    - (e) duo-binary and partial response encoding techniques

D. Communication Links and Modes of Operation

1. Modes of operation
    - (a) simplex mode
    - (b) half duplex mode
    - (c) full duplex mode

2. Types of data networks
    - (a) switched network
        - (i) advantages and disadvantages
    - (b) dedicated network
        - (i) point to point communications link
        - (ii) advantages and disadvantages

E. The Data Communications Channel

1. Levels in data communications
    - (a) TLP — transmission level point
    - (b) DLP — data level point (1-13 dBmO)
    - (c) Tx and Rx levels in a system

2. Parameters affecting data communications
    - (a) systematic and fortuitous distortions
    - (b) attenuation distortion
        - (i) definition
        - (ii) measuring and equalizing for amplitude distortions

- (c) envelope delay distortion
  - (i) definition
  - (ii) measuring relative envelope delay
- (d) impulse noise
  - (i) definition
  - (ii) impulse noise measurement
- (e) phase jitter
  - (i) definition
  - (ii) phase jitter measurment
  - (iii) phase hit measurment using an impulse noise counter

3. Circuit conditioning
   - (a) requirements for line conditioning
   - (b) types of conditioned data circuits
     - (i) schedule 4 type 4
       - — parameters
       - — data speed accommodation
     - (ii) schedule 4 type 4A
       - — parameters
       - — data speed accommodation
     - (iii) schedule 4 type 4B
       - — parameters
       - — data speed accommodation
     - (iv) schedule 4 type 4C
       - — parameters
       - — data speed accommodation
     - (v) transmission arrangements to accommodate speed to 50kb/s

F. Data Modem

1. Basic description of a data modem
   - (a) function of a modem
   - (b) basic elements of a modem
     - (i) transmitter section
     - (ii) receiver section
     - (ii) control and timing section
   - (c) asynchronous and synchronous transmission
   - (d) classification of modem types
     - (i) low speed
       - — sub voice grade — VFCT
       - — voice grade tp 1800 b/s
     - (ii) medium speed
       - — voice grade modems
       - — 2400 to 9600 b/s transmission
       - — examples
     - (iii) high speed
       - — wideband modems and facilities
       - — typically 19.2 Kb/s and 50 Kb/s
       - — examples

2. Basic modulation techniques
    - (a) amplitude modulation
        - (i) amplitude shift keying
        - (ii) vistigial sideband
    - (b) frequency modulation
        - (i) frequency shift keying — 103 modem
    - (c) phase modulation
        - (i) phase shift keying
    - (d) multilevel AC coding techniques
        - (i) multilevel phase modulation techniques — Bell 201 modem
        - (ii) multilevel phase and amplitude modulation techniques — QAM for 9600 bps modems
    - (e) advantages of phase modulation
        - (i) fixed reference detection
        - (ii) differential detection

3. Acoustic couplers

4. E1A interface
    - (a) functions, types and general descriptions
    - (b) standard voltage levels
    - (c) individual lead function

5. The data access arrangement for the switched network

6. The data transmission test set (demonstration)

G. Digital Data Networks

SUGGESTED REFERENCE MATERIALS

Basic Electronics by Grob — McGraw Hill — 5th Edition

Basic Mathematics for Electronics by Cook and Adams — McGraw Hill — 4th Edition

Electronic Principles by Malvino — McGraw Hill — 2nd Edition

Mathematics Applied to Electronics by Harter and Beitzel — Prentice Hall

Digital Principles and Applications by Malvino and Leitch — McGraw Hill — 3rd Edition

TECHNICAL TRAINING SCHOOLS

The Communications Electrician apprenticeship training program is offered by the Alberta Manpower, Apprenticeship and Trade Certification Division. Staff and facilities for teaching the program are supplied by:

1. Northern Alberta Institute of Technology
2. Southern Alberta Institute of Technology

LOCATION OF APPRENTICESHIP AND TRADE CERTIFICATION DIVISION REGIONAL OFFICES

BONNYVILLE

CALGARY

EDMONTON

FORT McMURRAY

GRANDE PRAIRIE

HINTON

LETHBRIDGE

MEDICINE HAT

PEACE RIVER

RED DEER

VERMILION

GOVERNMENT OF THE PROVINCE OF ALBERTA

ALBERTA REGULATION 93/80

(Filed on March 14, 1980)

THE MANPOWER DEVELOPMENT ACT

DEPARTMENT OF ADVANCED EDUCATION AND MANPOWER

MINISTERIAL ORDER

I, James D. Horsman, Minister of Advanced Education and Manpower, pursuant to sections 30(2) and 37(2) of The Manpower Development Act, hereby make regulations in the Appendix attached hereto, being the Communication Electrician Trade Regulation.

Dated at the City of Edmonton, in the Province of Alberta, this 12th day of March, 1980.

JAMES D. HORSMAN,
Minister of Advanced Education and Manpower.

APPENDIX

THE MANPOWER DEVELOPMENT ACT

Communication Electrician Trade Regulation

1(1) In this regulation

(a) "communication electrician" means a person engaged in the construction, installation and maintenance of telecommunication systems;

(b) "General Regulations" means the General Regulations under The Manpower Development Act, (Alta. Reg. 43/77) as amended;

(c) "trade" means the trade of communication electrician.

(2) The definitions in the General Regulations apply in this regulation.

Part 1

APPRENTICESHIP AND TRADE TRAINING

2 A person is eligible to be an apprentice who has

(a) satisfied the requirements of section 5 of the General Regulations, and

(b) completed grade 11 with Mathematics 20 or its equivalent, or passed an entrance examination prescribed by the Board.

3(1) Subject to subsection (2), an employer who is a journeyman or employs a journeyman may employ one apprentice, and for each additional journeyman he employs, he may employ one additional apprentice.

(2) The Director may authorize an employer to employ an apprentice, in addition to those permitted under subsection (1), on a temporary basis, to train him in a branch of the trade not engaged in by the employer to whom he is apprenticed.

(3) An apprentice employed temporarily under subsection (2) shall not, for the purposes of subsection (1), be considered to be an apprentice of his temporary employer.

4(1) The term of apprenticeship shall consist of four periods of 12 months each.

(2) Each period referred to in subsection (1) shall consist of not less than 1800 hours of on the job training, inclusive of time spent attending technical courses prescribed by the Board.

(3) The Director may not, under section 25(1) of the Act, reduce the term of apprenticeship to be served by an apprentice to less than one period of apprenticeship.

5 When a contract of apprenticeship is registered with the Director, he shall issue to the apprentice an official record book referred to in section 14 of the General Regulations.

6(1) An apprentice shall not advance to the next period until the Director has authorized him to do so by making an entry in the apprentice's official record book under subsection (2).

(2) The Director shall make an entry in the apprentice's official record book authorizing advancement to the next period, when the apprentice

(a) has completed the previous period of apprenticeship,

(b) has received, in the opinion of the Director, a satisfactory report from

  (i) his employer, and

  (ii) the school at which he attended technical training courses prescribed by the Board,

(c) has completed the tests and examinations prescribed by the Board, and

(d) has attained pass marks prescribed by the Board, in the tests and examinations referred to in clause (c).

7 The official record book of an apprentice shall be kept in the possession of his employer and, upon termination of employment of the apprentice, the employer shall present the book to him.

8(1) An employer shall pay wages to the apprentice that are not less than the following percentages of the prevailing wages paid to a journeyman:

(a) 40% in the first period;

(b) 50% in the second period;

(c) 60% in the third period;

(d) 75% in the fourth period.

(2) Notwithstanding subsection (1), the wages paid to an apprentice shall not be less than the minimum wage fixed pursuant to The Alberta Labour Act, 1973.

(3) An employer is not required to pay an apprentice wages during the time that the apprentice spends attending technical training courses prescribed by the Board.

9 The hours of work and working conditions of an apprentice shall be the same as those of a journeyman.

Part 2

CERTIFICATION

10 In addition to section 32 of the General Regulations, the Director may issue a Certificate of Qualification for the trade of communication electrician without examination to a person who holds

(a) a Certificate of Completion of Apprenticeship in the trade issued by another province within Canada, or

(b) a Certificate of Qualification or a Certificate of Proficiency in this trade issued by another province within Canada bearing an Interprovincial Standards Red Seal.

11(1) An application to take an examination for a Certificate of Qualification shall be made to the Director.

(2) Documentary evidence acceptable to the Director shall be presented by an applicant for an examination showing that the applicant

(a) holds a certificate equivalent to an Alberta Certificate of Qualification issued by a recognized provincial authority outside of Alberta, or

(b) has at least 4 years of acceptable work experience in the trade.

(3) The applicant shall provide translations into the English language, acceptable to the Director, of credentials other than in English submitted pursuant to subsection (2).

12 Certificates of Qualification issued under this regulation are effective unless cancelled or suspended by the Director in accordance with sections 42 and 43 of the General Regulations.

13 Alberta Regulation 570/64 is repealed.

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